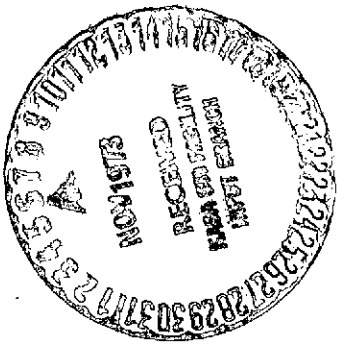
THE SPACELAB PROGRAM

J. P. Causse

Translation of: "Le Programme 'Spacelab'", Communication présentée au 24ème Congrès International d'Astronautique, Bakou, October 1973, 11 pages.



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16. Abstract

The Spacelab program is described beginning with conceptualization, through general organization, and on to users, shuttle interface, crew, models and configuration. The article underscores decisions required of European governments.

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Introduction

/1*

Spacelab is a habitable space laboratory (itself made up by a cabin, platform and various instruments) intended for transport into space by the American space shuttle. It is thus possible to tranform this shuttle at will into an orbital station at least for the period of one flight presently planned for between seven and thirty days. In this respect, Spacelab appears not only as the direct follow-on to Skylab which it will, in actual fact, come after in time but also undoubtedly as the forerunner of future orbital space stations when these become a reality.

Birth of the Spacelab Concept

It will be remembered that at the beginning of activity in what was then called the post-Apollo program, NASA was making plans for the simultaneous development of a new means of recoverable transport which was the space shuttle intended to considerably reduce the launch costs and the space station in the true sense allowing man to operate in space. The first concepts planned for the latter to be launched by Saturn V as Skylab. Then, plans called for a station constructed from components transportable by the shuttle although thought was likewise given to the utility of self-contained and independent modules. /2
However, as progress was made in specifications for the space shuttle itself, it appeared that it had many of the technical characteristics required for any space station. Its spacious bay 4.50 m in diameter and 18 m long is capable of accomodating a great variety of payloads. The Spacelab presently in the best defined one of the latter. When the shuttle is used in what is called the departure mode, the Spacelab is installed in the bay and the system is then placed in orbit by the shuttle (Figures 1 and 2). The Spacelab's own crew is

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*Numbers in the margin indicate pagination in the foreign text.

housed during launch in the shuttle. Once in orbit the shuttle opens the hatches of its bay inside of which are additionally installed the radiators intended to dissipate the heat produced within. The Skylab then carries out its mission. When the latter is fulfilled, the crew returns to the passenger seats in the shuttle which takes them back to the ground just like an aircraft. The Spacelab is now unloaded, rehabilitated and prepared for a new experiment. The shuttle undergoes a similar procedure and is made ready for the following flight which can be devoted to a completely different type of payload. The Spacelab is therefore not a self-contained space station like the Skylab.

General Organization of the Program

We shall try to point out here only a few advantageous features of this program. First of all, it involves a program of cooperation between Europe and the United States. By the signing of a Memorandum of Agreement between NASA and ESRO on 24 September 1972 in Washington, as well as by a series of agreements involving nine European governments between themselves and these same governments and the government of the United States, the responsibility for /3
development of the Spacelab was given to the European Space Research Organization (ESRO). The Europeans pledged to supply NASA, within the time limits agreed upon, one test model, one flight model as well as two complete sets of ground maintenance equipments. For its part, the United States government pledged not to develop similar systems and to later purchase in Europe the vehicles which it would need. These requirements are not presently accurately known but, provided present estimates are confirmed, they amount, with the components and spare parts to the equivalent of several units per year which will represent an already considerable industrial activity.

There is hardly any need to emphasize the unique character of this agreement which, for the first time, awards to a European agency an actual responsibility within a common program with NASA. American as well as European astronauts will fly in equipments constructed in Europe. This represents for us an intensely interesting program and a serious responsibility which we have naturally accepted (Figure 3).

The preliminary research was first started in America where the concept was born. It was then carried on in parallel in Europe and in the United States

and, since 24 September 1973, the Europeans alone have responsibility for the developmental research. We shall briefly describe the present situation and the general ideas concerning this project.

Transported by the space shuttle, the Spacelab also doubles as a means of /4
transport for those whom we shall call its users. We shall therefore successively take up the two main interfaces: the Spacelab with respect to the users and the Spacelab with respect to the shuttle.

The Users of Spacelab

A considerable effort has been made to try and specify the requirements. Since there is only one shuttle, it would be somewhat desirable to have only one Spacelab. However, its scope of employment is quite extensive (Figure 4). It stretches from the scientific exploration of space and from its utilization beginning from near and present state-of-the-art up to fields considered as very promising but totally new. For example, the future of manufacturing in space can only truly be placed in a firm foundation after a series of full-scale experiments which is just what Spacelab is going to make possible. A whole organization has been set up for collecting opinions and becoming familiar with the requirements of communities of users and there is a common NASA/ESRO working group which has the responsibility for expressing these requirements. Preference will probably be given to going ahead with the use of a series of standard components (Figure 5). Different solutions being investigated even contemplate a modular design allowing the quick assembly of the different components capable of making up the special craft intended for a specific mission with a minimum of control on the ground and rehabilitation after flight and compatible with the time of rehabilitation of the shuttle which is fourteen days between two flights. The detailed analysis of the users' requirements such as they have been expressed up until now has allowed defining the main features in each field. Figure 6 summarizes the requirements of the users.

The Interfaces with the Shuttle /5

Let us now take a look at the situation with regard to the shuttle. The latter obviously determines the features of dimensions (Figure 7). It also determines the available mass. Although this mass varies as a function of the

different orbits, the practical limit in the case of Spacelab comes from the limiting mass at landing imposed by the shuttles: 14,500 kg. Taking a margin of safety, we have in turn presently allocated only 11,500 kg to the industrial firms carrying out the research. In general, the shuttle is capable of placing in orbit a greater mass (up to 30 tons for a shot to the east of Cape Kennedy). It is also true that some consumable substances will be able to be carried in addition to the above mentioned mass. On the other hand, the center of gravity of this mass should be located within rather strict limits, placed well towards the rear of the shuttle, and given due consideration to conditions of aerodynamic stability during reentry.

However, although the shuttle introduces constraints, it is likewise capable of providing assistance to the Spacelab. It is clearly sought to make them both self-contained with respect to each other so as to simplify assembly, testing as well as the preparation and organization of experiments. On the other hand, the shuttle has as its goal the supply only of equipments common to the system of payloads. However, research on the system has showed that it is advantageous to make use of some of the installations of the shuttle. This is why it was decided that one of the three liquid hydrogen-oxygen fuel cells would be assigned to supply all of the electrical power required for Spacelab and the embarked tanks of the shuttle were consequently so designed. This power will naturally be used in the thermal form and the radiators installed on the shuttle have been designed to as to be able to ensure this dissipation. In accordance with our request, small guidance rockets with about 10 kg of thrust were installed on board the shuttle in order to supplement the main altitude control rockets whose thrust is in the vicinity of 500 kg. It will then be possible to aim the Spacelab shuttle system towards any point in the sky with an accuracy of about 0.5° and with limiting cycles not exceeding 0.1°. In this way, there will be made available a platform which is already remarkably stable and from which it will be relatively easy to aim scientific instruments. These latter will naturally be able to themselves supply the necessary supplementary pointing accuracy which will be required.

The capability for regenerating air onboard the shuttle would likewise be sufficient for the Spacelab. However, here research is still in progress

and it is more than likely that the autonomy of Spacelab will, on the contrary, be maintained owing to reasons of complexity of interfaces as well as safety.

It is likewise contemplated to use all or part of the computing capability available onboard the shuttle which is not used during orbital flight but is, on the contrary, used during the launch and reentry phases, i.e., at a time when Spacelab is not in operation.

Finally, we must remember that it is the shuttle which ensures communications with the ground. /7 On this subject, one important point remains to be settled. Shall these communications (in the KU band) be performed by relay using special telecommunications satellites ensuring practically permanent communications between the shuttles in flight and a central operations station or shall they be performed as they are today (in the S band) directly passing through a series of ground stations distributed throughout the world?

The Spacelab Crew

Let us now take up the role of the man onboard. The crew of the shuttle in its true sense is made up of three persons: one commander, one pilot and one mission specialist carrying out the functions of navigation, etc... This personnel is generally not available for carrying out Spacelab missions. It does, however, have the responsibility for carrying out the tasks assigned to the shuttle with respect to the Spacelab. The analysis of the requirements, as well as that for the shuttle's capabilities, has led to specifying a maximum of four persons for the crew of Spacelab. It will therefore be possible to have a total of seven men (or women) onboard. The crew of the shuttle will undergo astronaut training whereas the crew of Spacelab will probably be made up of scientists, engineers or technicians since the onboard flight conditions will not require an intensive training. The composition of the crews and the exact role played by man are among the most interesting subjects now being studied.

The Different Spacelab Models /8

We can probably delineate the different configuration types of Spacelab (Figure 8) as follows:

1) A module with relatively reduced dimensions associated with a large platform. This is the model which will undoubtedly be suitable for solar and stellar astronomy carried out in the ultraviolet and infrared ranges as well as for physics of the upper atmosphere and study of the earth, etc... It will be operated by two or three specialists on each shift.

2) A pressurized module with maximum dimensions, having a four-man crew working in two-man teams, will undoubtedly be suitable for biological research as well as for technical and technological investigations, especially with reference to manufacturing in space. In this case, it is possible for the power from one fuel cell not to be sufficient and an auxiliary cell will have to be installed on a platform component attached to the module.

3) One mode is also planned wherein the Spacelab is limited to the platform alone for some specific experiments where the role of the embarked man is limited or even when the recovery of data can be done either by telemetry or by ground recovery of films, magnetic tapes, etc. (Figure 9). This is the mode most suitable for some specific heavy experiments and which is especially requested by specialized investigators engaged in the study of high-energy particles. In this case, there undoubtedly can be only one specialist for the payload and who will then be located in the cockpit of the shuttle obliged to make do with a reduced control panel and a limited number of specific equipments.

The Possible Configurations /9

It is difficult to state exactly today what will be the configuration of Spacelab and what will be its technical characteristics. Indeed, two competing European industrial groups are presently conducting definition research (phase B) (Figure 10). In a part one, ending in the month of July 1973, they have made a first approximation of the problem and supplied a cost estimate on the basis of which the European governments have been able to pledge production of Spacelab in accordance with agreements with the United States. In the phase presently underway (phase B3), they should be reviewing the solutions taken with respect to first-phase results. They should undertake a rather detailed study at the subsystem level. This phase B will be completed at the end of February 1974 and only then will an industrial crew be made available for the

launch of the research and developmental stage in its true sense, planned for the month of June 1974. Only at that time will it be possible to know all of the main options concerning the Spacelab at the same time as the industrial team which will be entrusted with its development.

The approaches used by the two industrial groups can, nevertheless, be pointed out on a broad brush basis. The M.B.B. firm has designed an ingenious system whereby the structure of the module is divided into two parts. One of these, including the main part of the envelope, contains the equipments common to all the vehicles (Figure 11). The other part, constructed around the side /10
opposite to the shuttle, includes the platform in its true sense, exposed to empty space, and, on the inside side, another platform which carries the equipments specific for each payload. It will be possible to combine any common part at will with the various carriers of experiments. The latter can then be completely prepared in a laboratory or scientific institution and transported ready for integration and assembly with the common part just before launch time. This system can be produced with modules of different lengths.

The ERNO group has proposed a design wherein the Spacelab is produced in cylindrical modular components which can be simply assembled by joining ends (Figure 12). One of these contains components in common with one of the remaining components containing a payload or type of experiment. This system lends itself naturally quite well to development in various lengths. The platform is likewise modular.

Before definitely deciding on one configuration, it appeared necessary to see if other solutions were not still possible. The very question of the diameter to be given the Spacelab module is still open. Perhaps the maximum diameter should be selected since it would obviously allow more spacious inside accomodations but would in turn lead to large-volume components which would be difficult to transport. On the other hand, possibly a slightly smaller diameter should be preferred which would be consistent with the customary standards used by railroads or transport aircraft.

Conclusion /11

Little by little all of these decisions will have to be made. They will then allow choices to be made regarding the subsystems. The goal, naturally, is to develop a Spacelab acceptable to NASA, capable of finding a large number of users, capable of growth and slow evolvement, all this under conditions of perfect safety and naturally by making maximum use of techniques available in Europe and at the same time respecting the bounds of financial capabilities of the European governments. Such is our problem presented by Spacelab.

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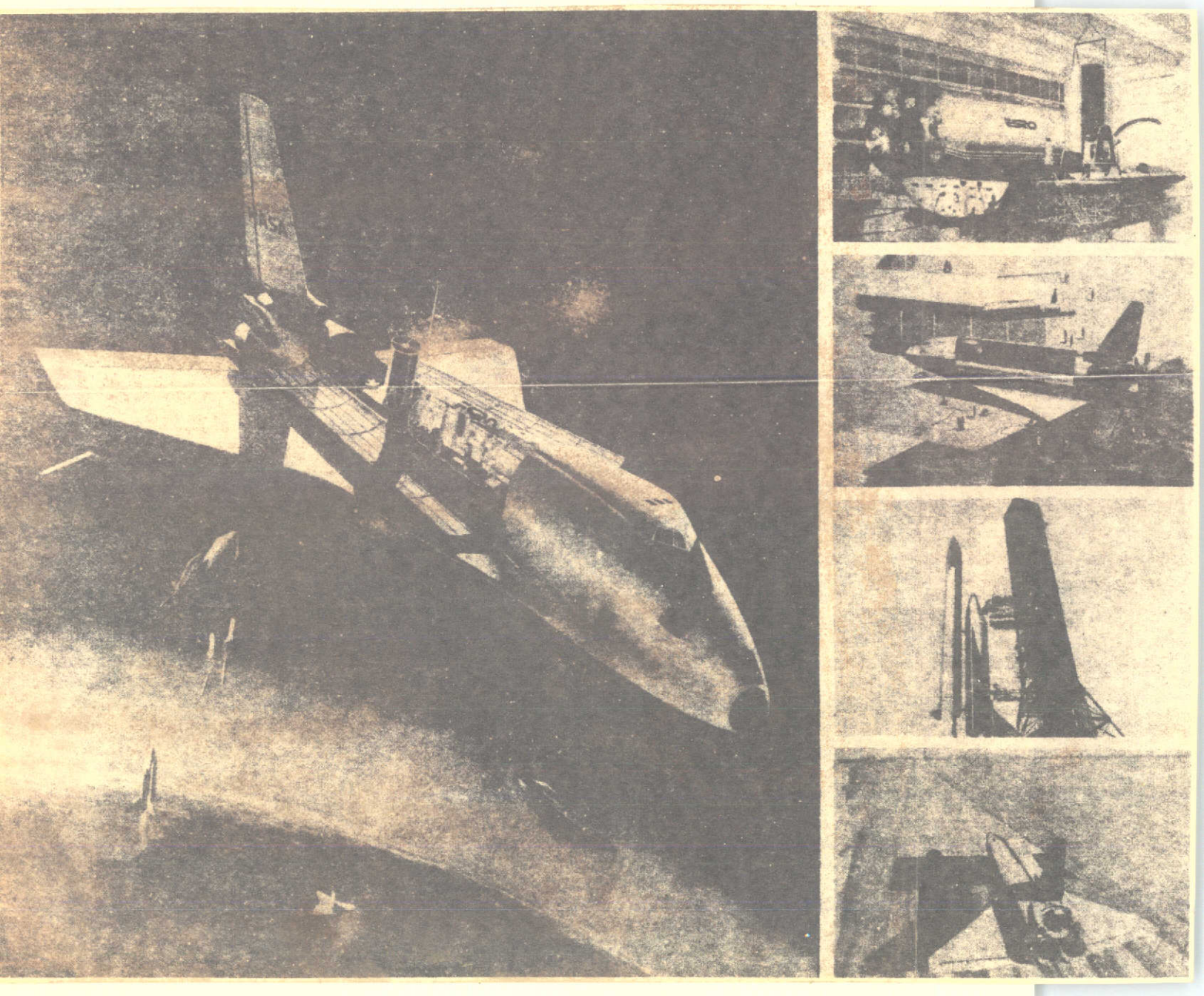


Figure 1.

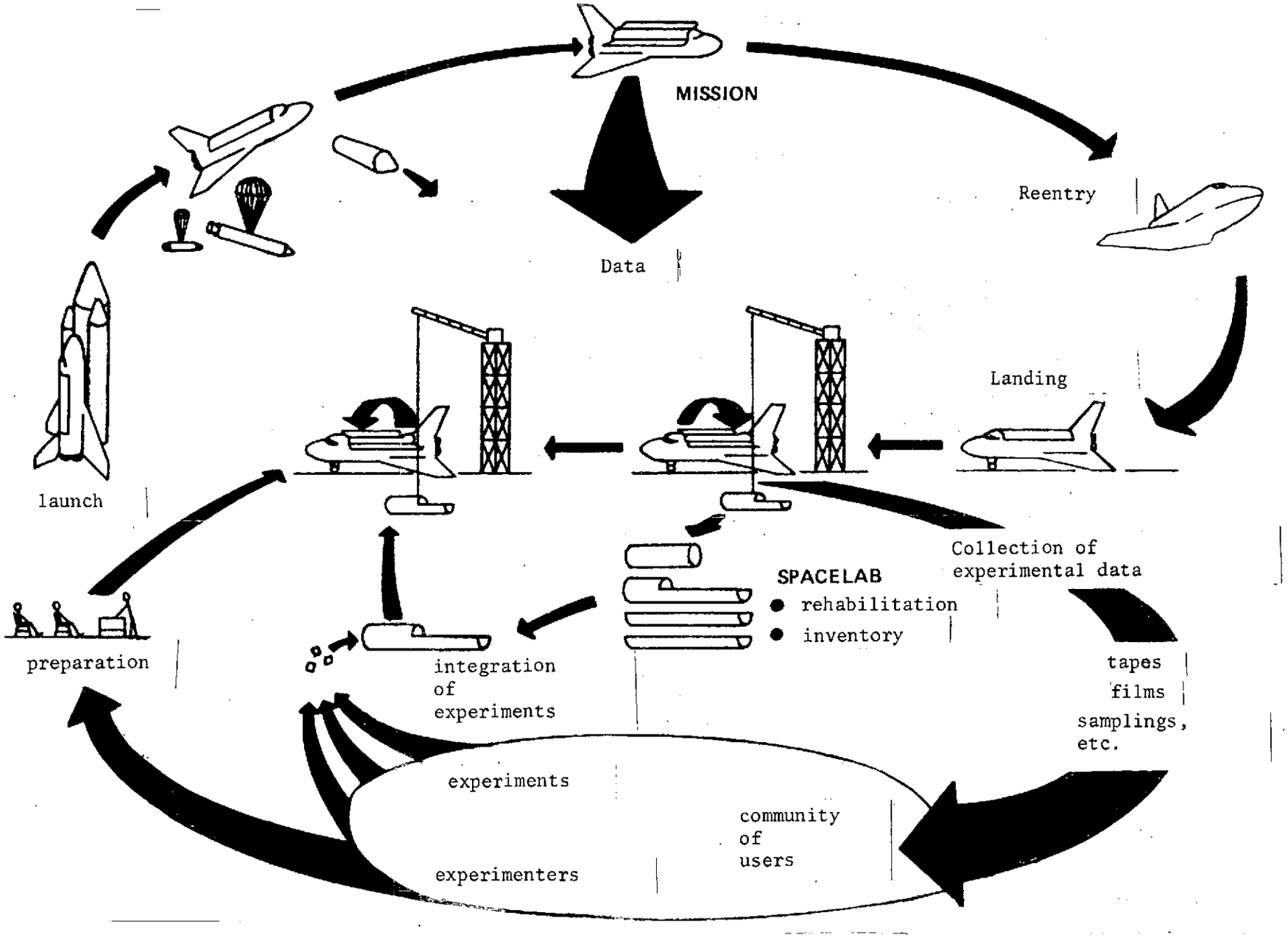
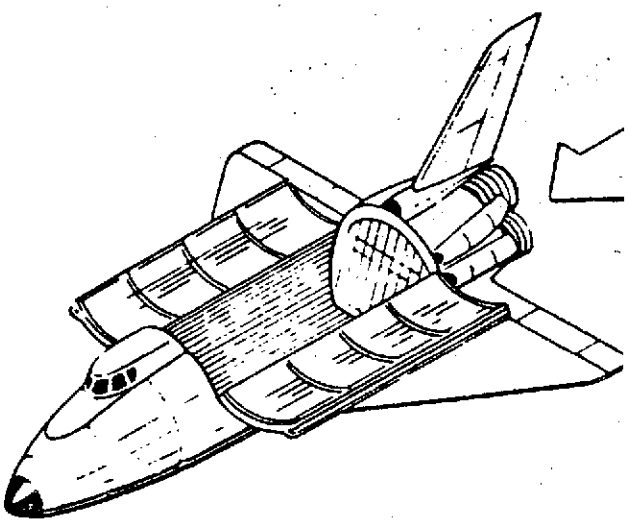


Figure 2. Mission — Spacelab Type.

shuttle



USA: development and operations

Europe: uses on basis of cooperation or cost compensation

Figure 3. The Cooperation Principle with Spacelab.

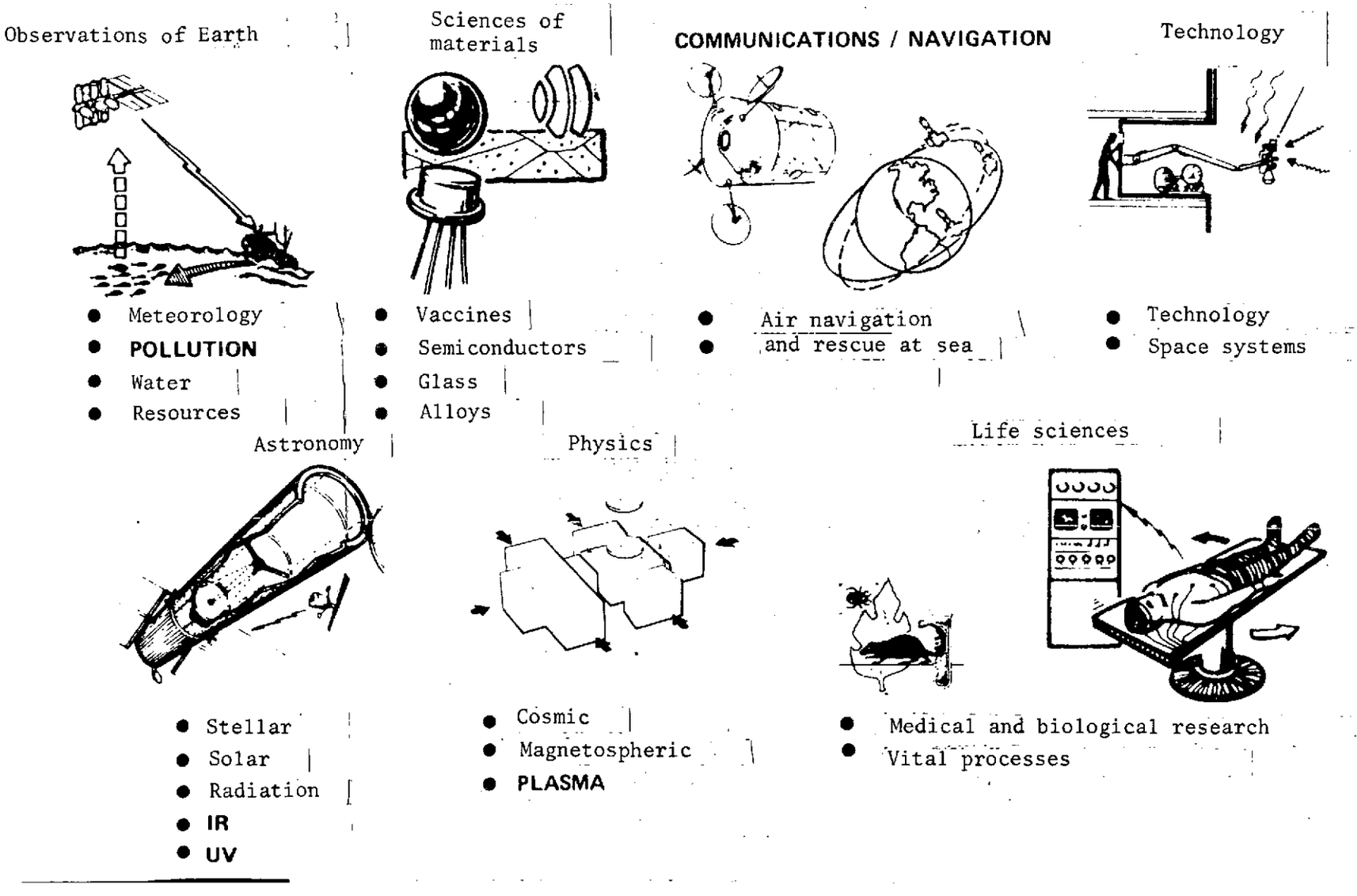
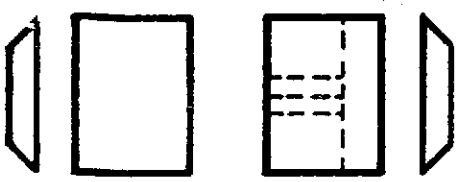


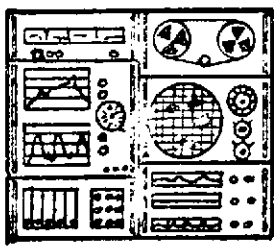
Figure 4. Uses of the Spacelab.



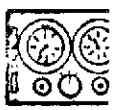
Support module (one)

Experimental module (s) (several)

Platform components (several)



Common support equipment for payloads (standard)



interface unit for single-platform missions (one)

Figure 5. What Is A Spacelab?

To supply maximum capabilities and flexibility to the community of users

- Flight versions desired
  - Single large module
  - Small module
  - Single platform

  } and combinations of the latter

  Platforms in segments to allow use of separate components
- Crew: 1 to 4 or, nominally, 2 + 2 for 12 hour watches
- Common maintenance and service equipment

  EX: locks, EVA devices, stabilized platform, porthole fittings, storage and processing of data
- To maximize weight (9100 kg max) and electrical power (4 kW mean, 10 kW max) available for users.

Figure 6. Requirements/Desiderata of Users for Phase B3.

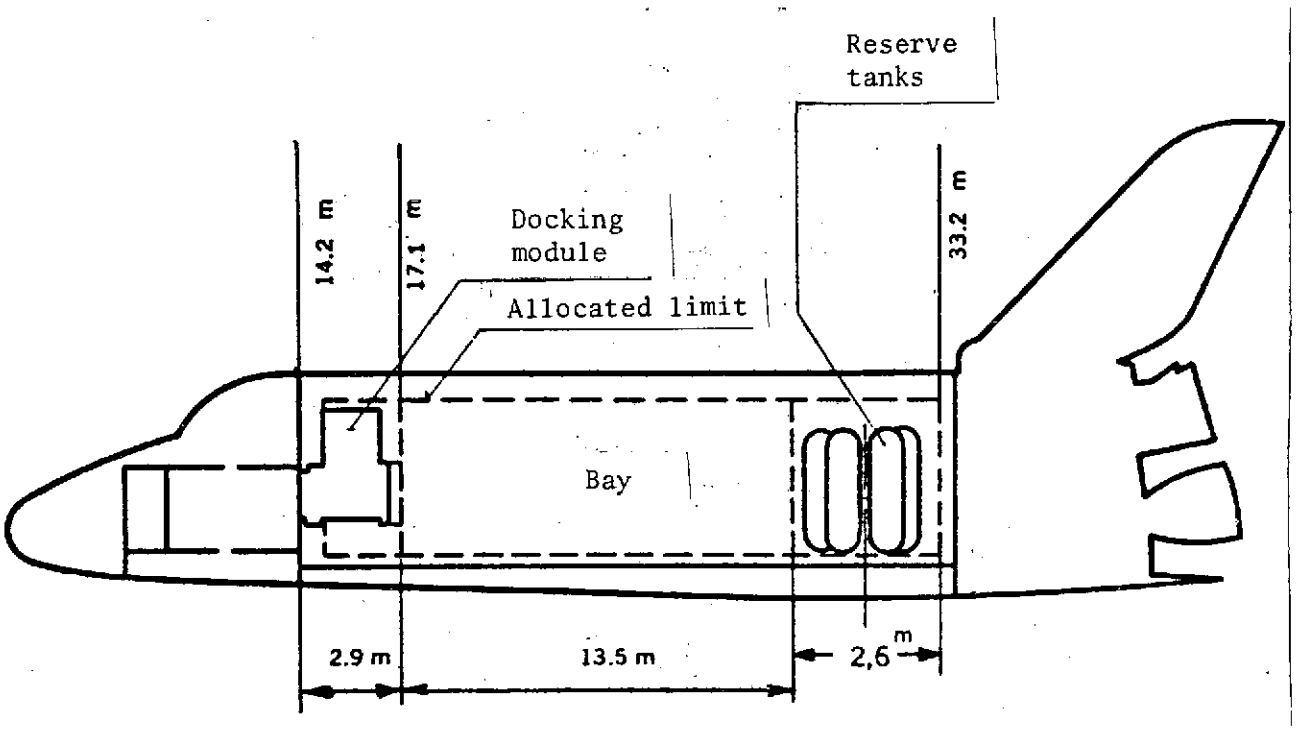
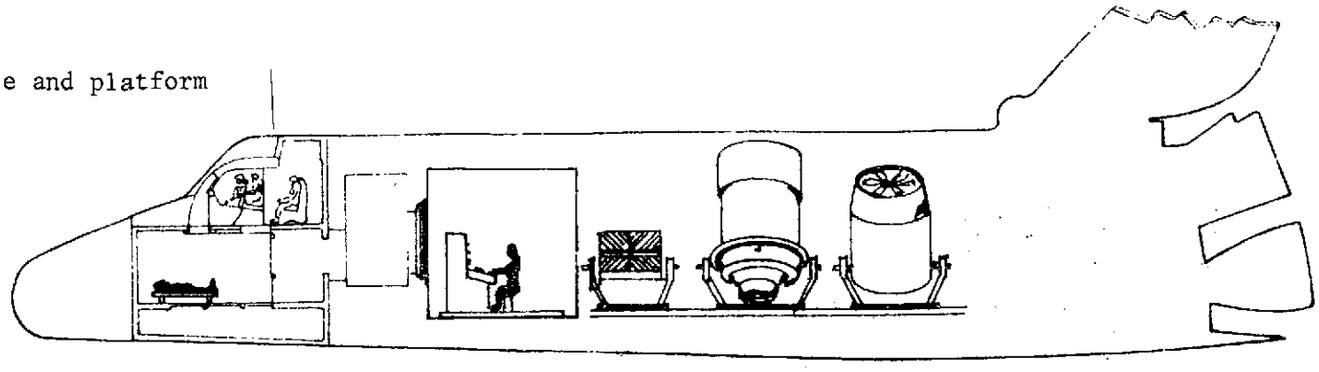
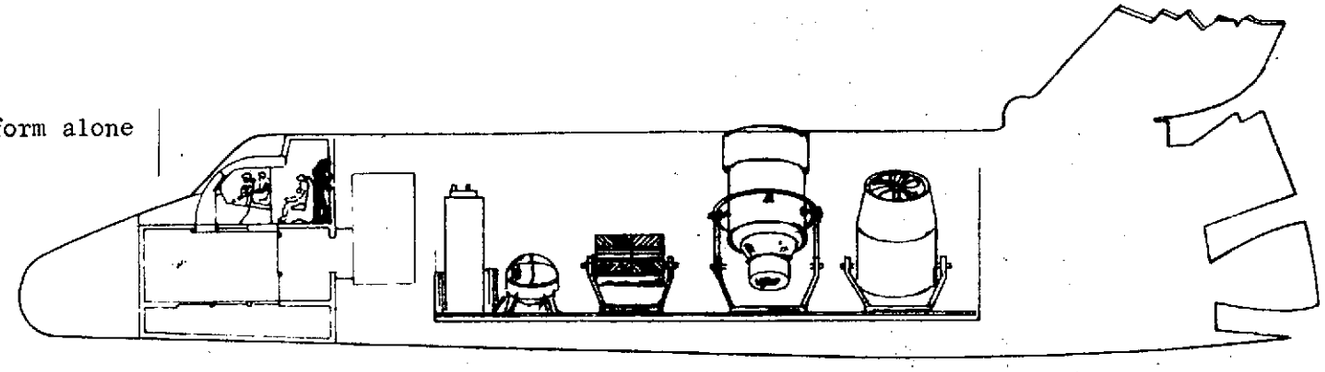


Figure 7. Maximum Dimensions Allocated Spacelab.

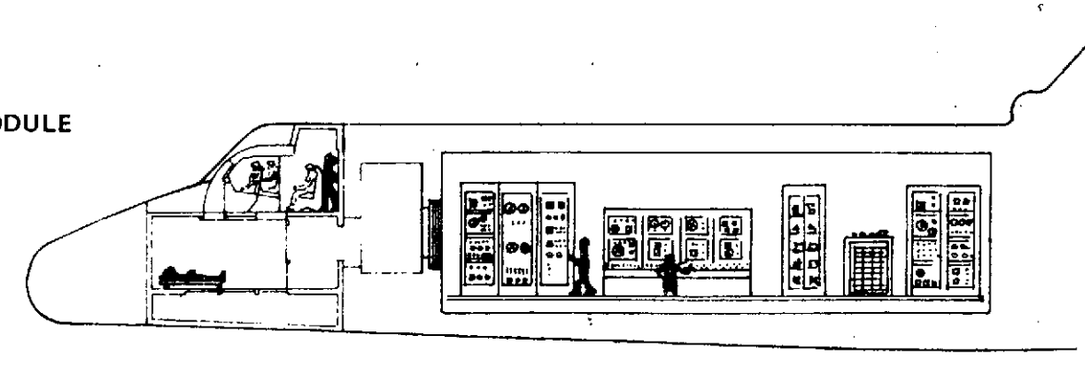
Module and platform



Platform alone



MODULE



Crew of Spacelab

Payload specialists

Crew of shuttle

Commander

Pilot

Mission specialist

Total number of embarked men

	Shuttle	SPACELAB
MODULE	3	2 · 4
Platform alone	3	1
Module + Platform	3	1 · 4

Figure 8.

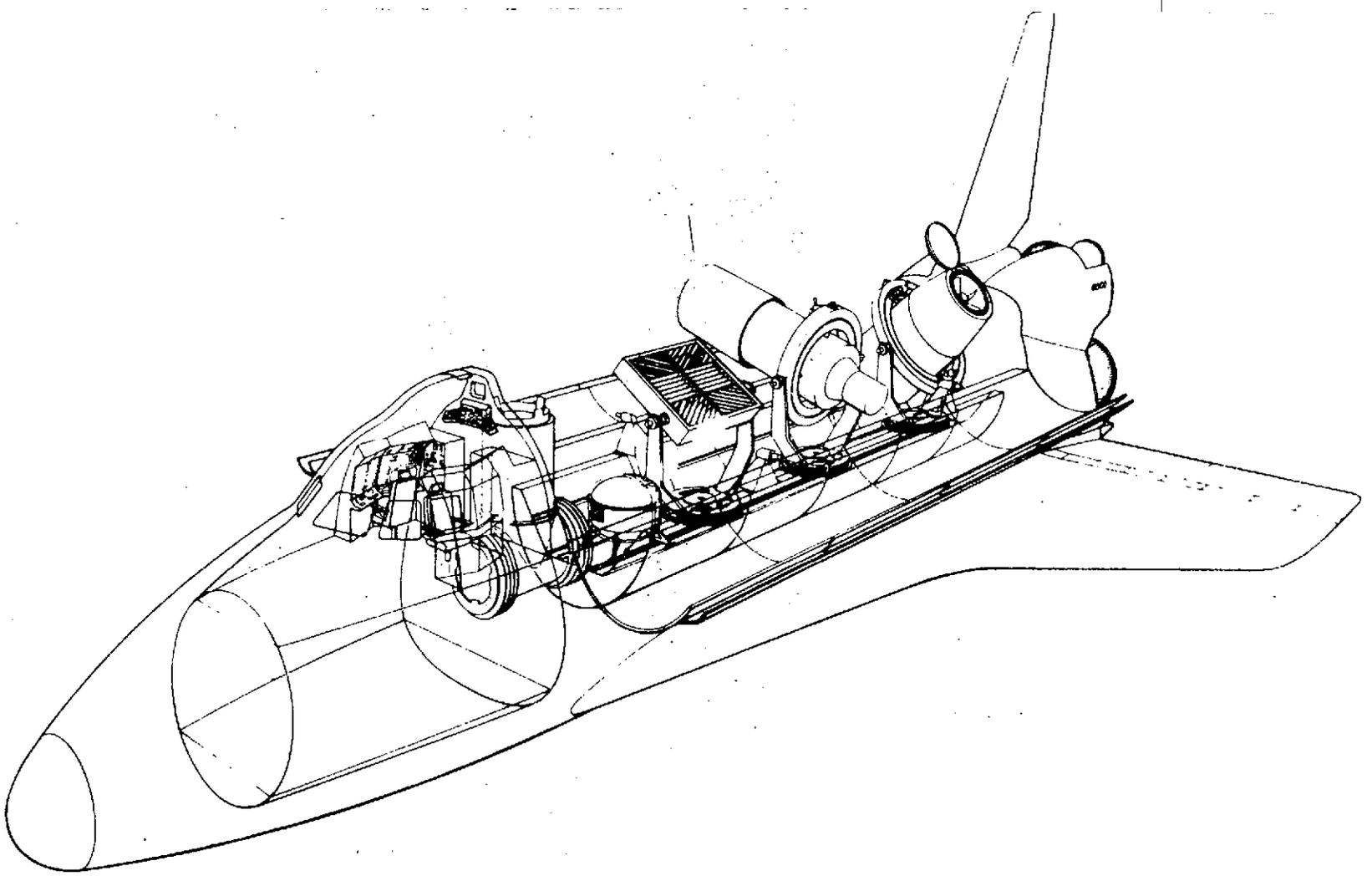


Figure 9. Single-platform Mission.

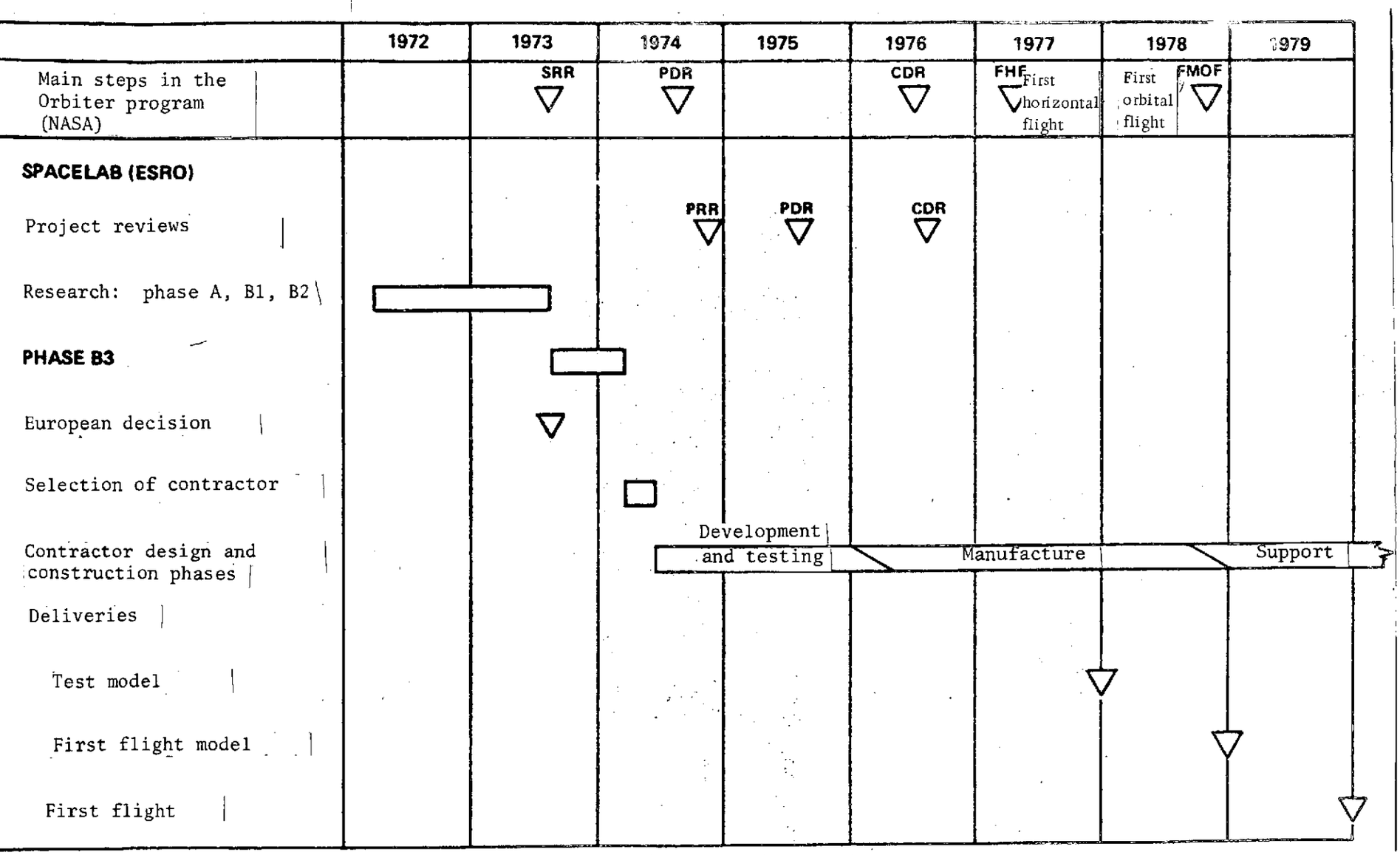


Figure 10. Planning Chart for the Spacelab.

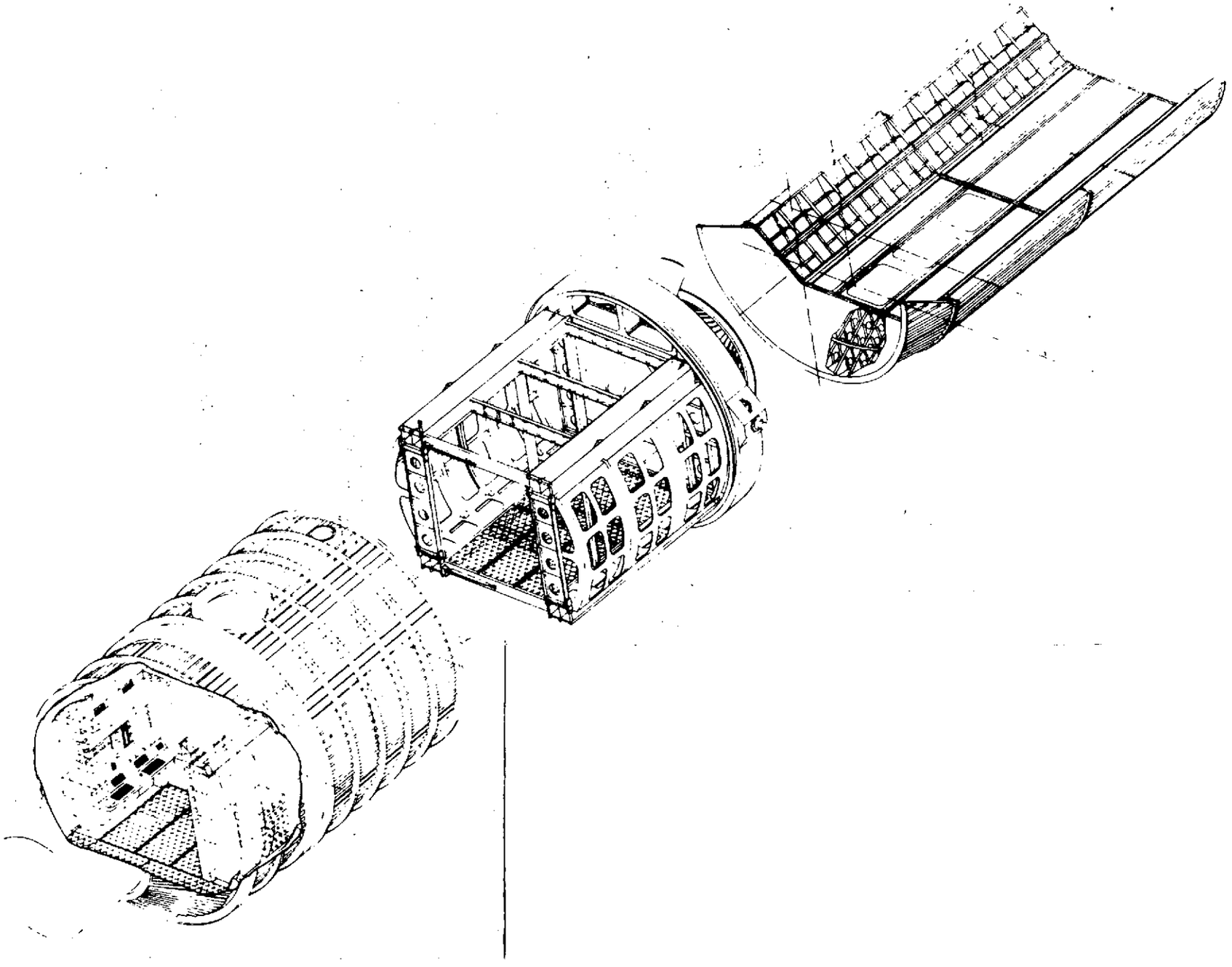


Figure 11. Common Support System and Integrated Payload System.

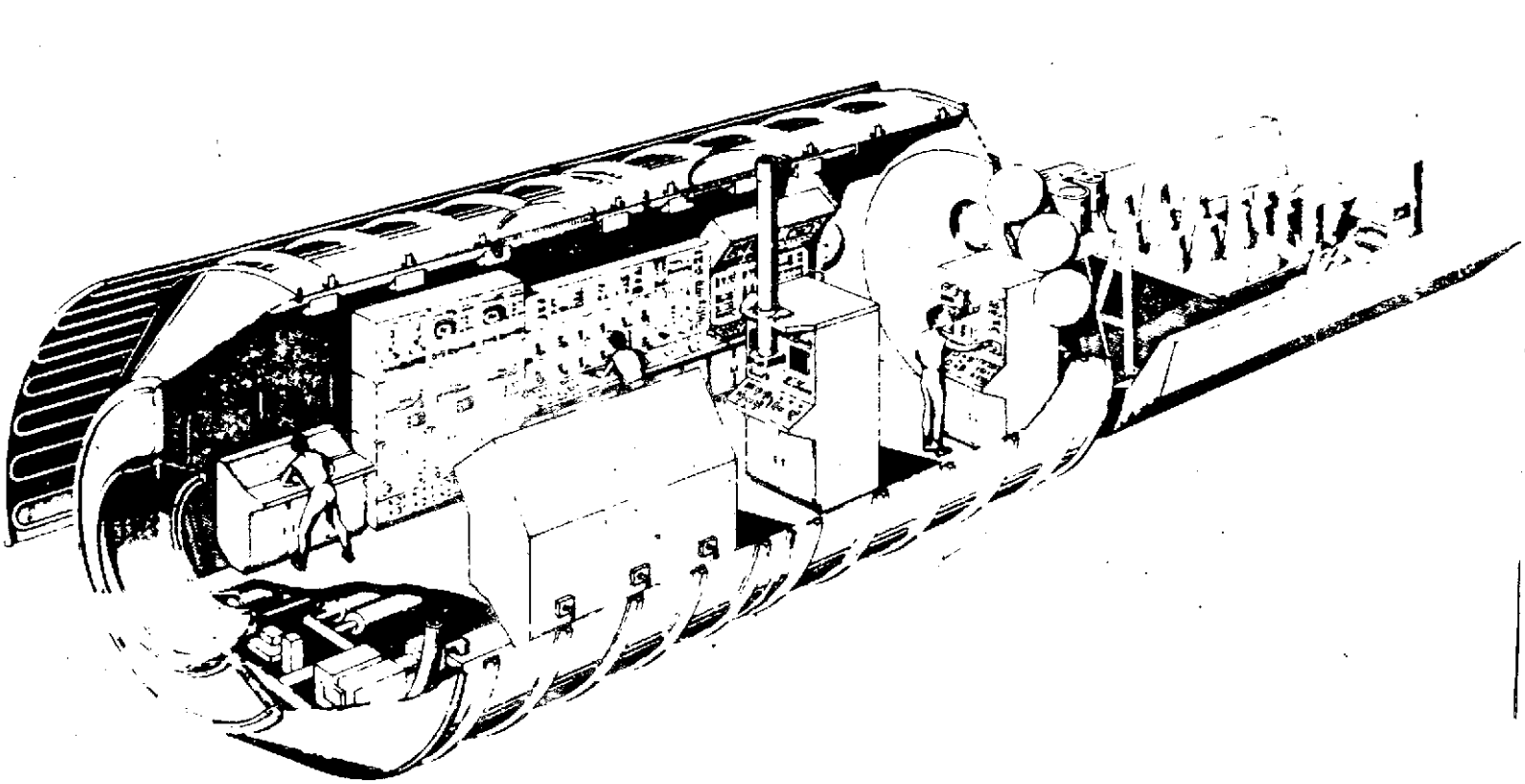


Figure 12. Principle of a Modular Spacelab.